Helminths from the Exotic Game Birds of the Puuwaawaa Ranch, Hawaii[1]

V. LEWIN[2] AND J. C. HOLMES[2]

OWNERS OF THE PUUWAAWAA RANCH have undertaken perhaps the largest bird importation and release program ever conducted by a private organization. During the past decade more than 2,600 upland game birds belonging to 33 species have been liberated on this large cattle ranch.

An ecological survey with emphasis on the origin, release site, present distribution, and reproductive phenology of these exotic birds was conducted between May 15, 1966 and June 1, 1967. Details of each release and the present distribution of all upland game birds in this area may be seen in Lewin (1971).

The Puuwaawaa Ranch is located on the western or leeward side of the island of Hawaii and lies on the northern slope of the dormant volcano Hualalei. The central portion of the ranch, where most of the birds were collected, lies between 1,000 and 3,000 feet in elevation and is bounded on the eastern side by the lava flow of 1859, which originated from Mauna Loa to the south, and on the western side by the undated but much older Kaupulehu flow.

The annual rainfall of this area is variable; at elevations of 4,500 feet it has been as much as 97 inches and as little as 18 inches (Taliaferro, 1959). At low elevations, on the almost barren lava flows along the coast, desert conditions prevail with the average annual precipitation being 8 inches. However, at middle elevations, precipitation averages about 25 inches annually.

The upper, moist slopes are characterized by large koa trees (*Acacia koa*), with an increasing number of ohia lehua (*Metrosideros collina*) and of smaller mamani trees (*Sophora chrysophylla*) occurring as one proceeds toward slopes of middle elevation. Near the 3,000 foot level the ohia trees are more widely spaced and a thick cover of exotic kikuyu (*Pennisetum clandistinum*) and pampas grass (*Cortaderia selloana*) gives the landscape a savannahlike appearance. At elevations near and below 2,000 feet the dominant trees are the exotic keawe—algaroba or mesquite (*Prosopis chilensis*) and the rare endemic wiliwili (*Erythrina sandwicensis*). The exotic range pests lantana (*Lantana camara*), castor (*Ricinus communis*), and panini or prickly-pear cactus (*Opuntia megacantha*) are frequently found in impenetrable masses in lowland areas.

Puuwaawaa Ranch was purchased in 1958 by its present owners, Lowell Dillingham and Wendell Carlsmith, who started this unique bird importation program by constructing, to date, 43 sanctuaries, which are fenced areas provided with food, water, and cover. Intensive predator control is practiced in these areas. The sanctuaries also serve as release sites for newly imported birds and as congregating areas for the many game birds which have become established on this ranch.

Congregating areas, such as the sanctuaries, provide opportunities for the exchange of parasites among the many species of birds found there. Newly introduced birds may bring new types of parasites with them and/or may acquire parasites from the birds already established. A number of introduced Galliformes were killed for reproductive information; this provided an opportunity to investigate the helminths of the same birds to determine whether any have been successfully introduced into Hawaii and to what extent helminths are being exchanged among the various species of Galliformes now found on the ranch.

METHODS

Most of the birds were shot in the vicinity of the sanctuaries; some were obtained alive

[1] Manuscript received November 15, 1970. This research was supported by National Research Council of Canada operating grants A-2080 and A-1464.

[2] Department of Zoology, University of Alberta, Alberta, Edmonton, Canada.

from the predator traps in the area. All birds were autopsied by V. Lewin within 1 to 4 hours after collection.

The eyes were examined by passing a blunt probe under the nictitating membrane and upper and lower eyelids to remove eye worms. Eyeballs were removed later, cut open, and examined. Internal organs, such as the nasopharynx, buccal cavity, trachea, esophagus, proventriculus, ventriculus, small intestine, ceca, large intestine, bursa of Fabricius (if present), cloaca, heart, kidney, liver, lung, and body cavity, were examined by conventional means. Each organ, including both in the case of paired organs, was examined completely and all parasites were collected. All parasites were relaxed in cold water, then transferred to AFA (alcohol-formalin-acetic acid) or Bouin's fixative. They were stored in these solutions until shipment to Canada.

In the laboratory in Edmonton, J. Holmes counted, prepared, and identified all specimens. Trematodes and cestodes were stained in Semichon's acetocarmine and mounted in balsam. Nematodes were cleared and examined in temporary mounts in a mixture of methyl salicylate and beechwood creosote.

RESULTS

One hundred fifteen Galliformes, belonging to seven species, were examined for helminths. A total of 11 species of helminths, including one species of trematode, four cestodes, and six nematodes, was recovered. The numbers of each species of bird examined, the species of helminths recovered, and data on the prevalence and intensity of infection of each helminth are given in Table 1.

Trematodes

Philophthalmus gralli Mathis and Leger, 1910. One specimen was found in the orbit of a pheasant. Alicata (1969) listed this fluke from coots (*Fulica americana alai*) and cattle egrets (*Bubulcus ibis*) in Hawaii; elsewhere, it has been found in ducks and chickens (Ching, 1961; Krygier and Macy, 1969). This is apparently the first record from a ring-necked pheasant. Birds acquire the infection by ingesting metacercariae encysted on vegetation (Alicata, 1964).

Cestodes

Orientolepis exigua (Yoshida, 1910). Fragments recovered from the small intestine of one turkey were assigned to this species by the characteristic morphology of the mature proglottids (Spassky and Jurpalova, 1964). No scolices or gravid proglottids were present. This species has been reported as *Hymenolepis exigua* or *Hymenosphenacanthus exiguus* from chickens from various places in the Pacific, including Hawaii (Alicata 1964, 1969). It has not been reported previously from turkeys. Alicata and Chang (1939) found that the amphipod *Orchestia platensis* was the intermediate host in Hawaii.

Metroliasthes lucida Ransom, 1900. This species, a very common parasite of both wild and domestic turkeys (Reid, 1962; Maxfield, Reid, and Hayes, 1963), was found only in turkeys. It has not been reported previously from Hawaii.

Choanotaenia infundibulum (Bloch, 1779). This tapeworm, a common parasite of chickens in Hawaii (Alicata, 1964), was found in three of the species examined in this survey. It, together with *Fuhrmannetta crassula,* was found in adult birds only. It is widespread throughout the Galliformes, and has been reported previously from all three of these hosts (Kasimov, 1956; Chandler, 1970). Intermediate hosts in Hawaii include houseflies and several species of beetles (Alicata, 1964).

Fuhrmannetta crassula (Rudolphi, 1819). Single specimens were found in three California quail. This species is a characteristic parasite of Columbiformes, but has been reported from Galliformes on occasion (Artiukh, 1966). It has not been reported previously from California quail or from Hawaii, although Alicata (1969) reported an unidentified species of *Raillietina* from pigeons (*Columba livia*) in Hawaii. In addition, Schwartz and Schwartz (1949) reported that tapeworm infections were common in Chinese doves (*Streptopelia chinensis*) and feral pigeons, but did not identify the tapeworms. Both species have been reported as hosts of *F. crassula. Fuhrmannetta* was previously regarded as a subgenus of *Raillietina,* but

TABLE 1

HELMINTHS RECOVERED FROM EXOTIC GAME BIRDS OF THE PUUWAAWAA RANCH, HAWAII

	Meleagris gallapavo, TURKEY	*Phasianus colchicus*, RING-NECKED PHEASANT	*Alectoris barbara*, BARBARY PARTRIDGE	*Coturnix coturnix*, JAPANESE QUAIL	*Lophortyx californica*, CALIFORNIA QUAIL	*Pternistes leucoscepus*, BARE-THROATED FRANCOLIN	*Francolinus pondicerianus*, GREY FRANCOLIN
Number of birds examined	5	2	3	3	82	1	19
Number of birds infected with*							
Trematodes							
Philophthalmus gralli		1 (1)					
Cestodes							
Orientolepis exigua	1 (1)						
Metroliasthes lucida	2 (5–34)						
Choanotaenia infundibulum			1 (4)	1 (12)	1 (1)		
Fuhrmannetta crassula					3 (1)		
Nematodes							
Oxyspirura mansoni	3 (1–14)	2 (19–27)	3 (4–14)		4 (1–10)	1 (1)	19 (6–69)
Oxyspirura sp.					2 (1–14)	1 (2)	
Dispharynx nasuta			1 (7)		5 (1–9)		
Aulonocephalus pennula					30 (1–82)		
Allodapa brumpti	1 (2)	1 (55)		1 (4)	1 (1)		4 (2–13)
Heterakis gallinarum		2 (2–20)					1 (1)

* Numbers in parentheses are the numbers of helminths per infected birds.

has been raised to full generic status by Movsessian (1966).

Nematodes

Oxyspirura (*Yorkeispirura*) *mansoni* (Cobbold, 1879). This eyeworm has a wide host range. In Hawaii, it has been reported from six species, including pheasant, Japanese quail, and chickens (Alicata, 1964). Elsewhere, it has been reported from 16 other species, including turkeys (Addison and Anderson, 1969). It was the most prevalent of the parasites found in this survey, was recovered from six of the seven species and from 28 percent of the 115 birds examined, and was particularly abundant in the grey francolins (Table 1).

The infections in the Barbary partridge, California quail, bare-throated francolin, and grey francolin appear to represent new host records.

In eight (two pheasants and six grey francolins) of the 32 birds infected with *O. mansoni,* a few specimens (one to eight) were found in the nasopharynx. These worms were the same size as those found in the orbits, and were more frequently found in birds with relatively heavy infections (three of 21 with 20 or fewer eyeworms, five of 11 with 21 or more). Their presence in the nasopharynx may have been due to post-mortem movement, since 2 to 4 hours frequently elapsed between collection and examination of the birds.

Alicata (1964) suggested that wild birds act as reservoir hosts from which infections in domestic chickens could be derived. The data in Table 1 support that suggestion. The intermediate host in Hawaii is the burrowing roach (*Pycnoscelus surinamensis*) which is common in relatively dry areas with loose sandy soil (Alicata, 1964), such as the study area.

Schwabe (1950) described the pathology produced in chickens by heavy infections with *Oxyspirura mansoni.* No obvious symptoms were found in the wild Galliformes, although 20 or more worms were found in 13 of the 28 infected birds, with over 60 worms found in two birds.

Oxyspirura (*Oxyspirura*) sp. Nongravid females of a second species of eyeworm were found in two California quail and in the only bare-throated francolin examined. Although species of *Oxyspirura* cannot be identified from females alone (Addison, personal communication), this species could be placed in the subgenus *Oxyspirura* (and therefore differs from *O. mansoni*) because of its undivided buccal capsule. No member of this subgenus has been reported from Hawaii or from either of the two host species.

Dispharynx nasuta (Molin, 1858). This proventricular nematode was recovered from only two of the species examined: Barbary partridge and California quail. Skrjabin, Sobolev, and Ivashkin (1965) reported it from Barbary partridge, but it has not been reported previously from California quail. In Hawaii, it also occurs in chickens, with infective larvae in sowbugs, *Porcellio laevis* (Alicata, 1964).

Dispharynx nasuta characteristically burrows deeply into the mucosa of the proventriculus, stimulating a proliferation of the tissues, and frequently ulceration, near the site of attachment. These changes were noted in the hosts examined in this study. Heavy losses of grouse (*Bonasa umbellus*) in the northeastern U.S. (Goble and Kutz, 1945) and of pigeons in Florida (Hwang et al., 1961) have been ascribed to *Dispharynx nasuta.*

Aulonocephalus pennula (Canavan, 1929). This nematode was found only in California quail, in which it was the predominant helminth. It was found in the cecum and, rarely, the small intestine. It has not been reported previously from Hawaii or from California quail. The life cycle is unknown.

Two species of *Aulonocephalus* have been described from scaled quail (*Callipepla squamata*) and Gambel's quail (*Lophortyx gambeli*) from the southwestern United States: *Aulonocephalus pennula* by Canavan (1929, 1931) and *A. lindquisti* Chandler by Chandler (1935), Campbell and Lee (1953), and Gullion (1957). *A. lindquisti* has also been reported from bobwhite quail (*Colinus virginianus*) (by Webster and Addis, 1945 and by Webster, 1947). Chandler appears to have been unaware of Canavan's species, and descriptions of the two are very similar, differing significantly only in the number of pharyngeal teeth

(four in *Aulonocephalus pennula,* three in *A. lindquisti*) and the number of parasuctorial papillae in the male (two pairs in *A. pennula,* three in *A. lindquisti*).

An investigation of the material from this study and of specimens of *Aulonocephalus* from the southwestern United States, including the type and paratypes of *A. lindquisti* (the type and paratypes of *A. pennula* apparently have been lost), indicates that only one species is present (Table 2). The pharyngeal teeth are not easily seen; most of the specimens appear to have four, but some have three or five. All males, including the type and paratype of *A. lindquisti,* have two pairs of parascutorial papillae, and all except one have a total of

TABLE 2

COMPARATIVE MEASUREMENTS (IN MM) OF *Aulonocephalus* FROM HAWAII AND THE SOUTHWESTERN UNITED STATES

	Lophortyx californica, CALIFORNIA QUAIL HAWAII THIS STUDY	*Callipepla squamata,* SCALED QUAIL PHILA. ZOO CANAVAN, 1929	*Lophortyx gambeli,* GAMBEL'S QUAIL PHILA. ZOO CANAVAN, 1931	*Callipepla squamata,* SCALED QUAIL TEXAS CHANDLER, 1935
Males	25			2
L. Body	6.0–15.4	5.5–7.5	11–12	9–10.6
W. Body	0.336–0.526	0.31–0.34		0.420–0.490
L. Tail (with spine)	0.248–0.380	0.34–0.36		0.370–0.430
L. Tail Spine	0.102–0.146	0.115		0.160–0.200
L. Anterior Vestibule	0.042–0.047			0.055
L. Posterior Vestibule	0.055–0.066			0.050
No. Esophageal Teeth	3–5	4		3
L. Esophagus	1.220–1.650	0.85		1.3–1.8
L. Esophageal Bulb	0.234–0.277	0.12–0.15		0.265–0.285
Percentage of Body Anterior to Nerve Ring	1.9–5.8			
Percentage of Body Anterior to Excretory Pore	2.9–9.0			
L. Spicules	0.876–1.241	0.93–1.04		1.16–1.30
L. Gubernaculum	0.142–0.164	0.185		0.170–0.190
No. Pairs Papillae	10–11	10 + 1	10	11
L. Preanal Sucker	0.190–0.219	0.170		
Females	26	8		3
L. Body	3.9–19.4	10.5–12.0	18–19	13–14.8
W. Body	0.204–0.672	0.41–0.51		0.530–0.590
L. Tail	0.949–1.513	1.26–1.30		1.35
L. Anterior Vestibule	0.022–0.055			0.055
L. Posterior Vestibule	0.026–0.073			0.050
No. Esophageal Teeth	3–5	4		3
L. Esophagus	0.467–1.752	1.04–1.38		1.3–1.8
L. Esophageal Bulb		0.20–0.22		0.265–0.285
Percentage of Body Anterior to Nerve Ring	2.1–5.2			
Percentage of Body Anterior to Excretory Pore	3.0–6.0			
Percentage of Body Anterior to Vulva	43–56	33		at or behind midbody
L. Ova	0.051–0.066	0.060		0.058
W. Ova	0.044–0.051	0.038		0.042–0.048

10 pairs of caudal papillae. One male recovered in this study (USDA Parasite Collection 66657) has an aberrant number of caudal papillae. The third pair of postanal papillae appears to be doubled: on the left, the extra papilla lies between the first and second postanal papillae; on the right, between the second and third. *Aulonocephalus lindquisti* Chandler, 1935 is, therefore, a junior synonym of *A. pennula* Canavan, 1929.

Allodapa brumpti Lopez-Neyra, 1922. This species, often referred to as *Subulura brumpti,* is a widespread parasite of domestic and wild

TABLE 2 (*continued*)

Callipepla squamata, SCALED QUAIL TEXAS — OUR MEASUREMENTS*	*Colinus virginianus,* BOBWHITE QUAIL TEXAS — WEBSTER AND ADDIS, 1947	*Lophortyx gambeli,* GAMBEL'S QUAIL NEVADA — USDA PAR. COLL. 49194	*Callipepla squamata,* SCALED QUAIL NEW MEXICO — USDA PAR. COLL. 48604	*Callipepla squamata,* SCALED QUAIL NEW MEXICO — USDA PAR. COLL. 48446
type, paratype		7	3	1
8.1, 6.5	8–10.6	10.1–14.7	9.6–10.4	6.24
0.307, 0.292		0.438–0.540	0.380–0.482	0.336
0.306, 0.394		0.277–0.394	0.292–0.350	0.277
0.117, 0.102		0.088–0.131	0.102–0.146	0.087
0.042, 0.037		0.044–0.051	0.042–0.044	0.037
0.051, 0.051		0.055–0.062	0.044–0.058	0.042
5, —		3–5	4	
1.066, —		1.226–1.401	1.139–1.343	0.964
0.201, 0.237		0.234–0.263	0.234–0.263	0.219
3.3, 3.5		2.5–3.1	3.2–3.8	4.2
5.1, —		3.5–5.0	4.4–5.3	5.4
1.096, 0.950		1.124–1.314	1.095–1.168	0.876
0.157, 0.146		0.157–0.164	0.146–0.153	0.164
10, 10		10	10	10
0.175, 0.204		0.190–0.219	0.190	0.201
type, paratype		7	3	8
11.4, 9.8	10–14.5	15.2–18.7	13.4–13.6	6.8–7.6
0.394, 0.409		0.511–0.672	0.438–0.584	0.336–0.394
1.022, 1.095		1.314–1.490	1.022–1.343	0.730–0.993
0.044, 0.044		0.051–0.058	0.048–0.055	0.037–0.044
0.062, 0.048		0.062–0.070	0.055–0.058	0.051–0.058
5, —		3–5	3–4	3–4
1.270, —		1.343–1.504	1.387–1.460	0.963–1.299
0.219, —		0.277–0.310	0.263	
3.2, —		2.2–2.8	2.5–2.6	3.2–3.9
4.5, —		3.0–3.8	4.0–4.1	5.1–6.4
46, 46	43–48	42–50	45–57	44–51
0.058, 0.058		0.062–0.069	0.066–0.070	0.062–0.066
0.048, 0.046		0.052–0.055	0.055	0.047–0.052

* Specimens dark and badly shrunken.

Galliformes (Levine, 1968); in Hawaii, it is the most prevalent of the cecal nematodes in chickens (Alicata, 1964), and has been reported from pheasants (Schwartz and Schwartz, 1951). In the present study, eight birds belonging to five species were infected; California quail and grey francolins appear to be new host records.

Allodapa brumpti requires an intermediate host. In Hawaii, several species of beetles, two grasshoppers, and an earwig have been shown to be satisfactory (Alicata, 1969).

Heterakis gallinarum (Schrank, 1788). Alicata (1964) reported this species of cecal worm to be common in chickens in Hawaii, where it has also been found in turkeys and pheasants. Although elsewhere it is widespread and occurs in a wide variety of birds (Madsen, 1950), including grey francolins (Bump and Bump, 1964) and California quail (Williams, 1966), we found it only in the two pheasants and one grey francolin. Unlike *Allodapa brumpti,* it has a direct life cycle, although it may use earthworms or sowbugs as transport hosts (Levine, 1968).

Heterakis gallinarum is primarily important as the vector of *Histomonas meleagridis,* the protozoan agent of "blackhead" (enterohepatitis), a disease frequently found in turkeys, but occurring in chickens and other Galliformes as well (Levine, 1961). *Histomonas meleagridis* occurs in Hawaii, where it causes sporadic outbreaks of enterohepatitis in turkeys (Alicata, 1964). Kellogg and Reid (1970) have shown that bobwhite quail and ruffed grouse may act as reservoirs for blackhead, or as transfer agents of blackhead between domestic fowl and wild turkeys in southeastern United States. The paucity of *Heterakis gallinarum* in this study would suggest that, on the Puuwaawaa Ranch, wild Galliformes (with the possible exception of pheasants) do not act as reservoirs of blackhead.

DISCUSSION

Four of the species of helminths recovered in this study (*Oxyspirura* sp., *Fuhrmannetta crassula, Metroliasthes lucida,* and *Aulonocephalus pennula*) have not been reported previously from Hawaii. Addison and Anderson (1969) list 62 species in the subgenus *Oxyspirura.* These come from a wide variety of hosts and localities; it is impossible to determine the source of the introduction of this species into Hawaii.

Fuhrmannetta crassula is primarily a parasite of Columbiformes, although it has been reported from chukars (*Alectoris graeca*) and coturnix quail (*Coturnix coturnix*) (Artiukh, 1966). It was probably introduced into the Hawaiian Islands early, with one or more of the several species of pigeons or doves.

It is highly probable that *Metroliasthes lucida* was introduced with the wild turkeys. The data in Maxfield, Reid, and Hayes (1963) and Self and Bouchard (1950) suggest that this tapeworm is more abundant in wild than in domestic turkeys.

Aulonocephalus pennula appears to be a very common parasite in various species of quail from arid regions of the southwestern United States (references cited earlier). The known distribution of this parasite includes south and west Texas, New Mexico, Arizona, and southern Nevada. Several species of quail resident in this area have been released on the Puuwaawaa Ranch. They include scaled, Gambel's, and bobwhite quail, all of which are known to be hosts of *A. pennula,* as well as elegant quail (*Lophortyx douglasii*) and harlequin quail (*Cyrtonyx montezumae*), which have not been reported as hosts.

Aulonocephalus pennula has not been reported previously from within the range of California quail, but no quail have been examined from the southeastern part of their range, where ecological conditions would be most similar to areas where *A. pennula* has been found.

The existing host records suggest that this parasite was introduced with other quail, which did not become established, and transferred to the more successful California quail. However, the possibility remains that *A. pennula* is a normal parasite of California quail in the southeastern part of their range.

Neither of the two helminths which were

apparently introduced with the exotic Galliformes are known to be pathogenic. The most pathogenic helminths we found, *Oxyspirura mansoni, Dispharynx nasuta* and *Heterakis gallinarum,* were apparently introduced into Hawaii much earlier, probably with domestic fowl.

Vertebrates introduced into new areas typically lose many of their parasites and gain a few others. The net result is usually a reduction in their parasite fauna (Dogiel, 1964; Hair and Forrester, 1970). Galliformes may be an exception since their parasites tend to be less specific, and related wild Galliformes and domestic fowl provide a reservoir from which the introduced birds can be infected. An example of this may be the parasite fauna of the California quail. We found seven species of helminths in 82 birds; Krogsdale (1950) found one species (*Rhabdometra odiosa*) in 41 quail from eastern Washington, Williams (1966) found three (*Hymenolepis* sp., *Heterakis gallinarum* and *Capillaria* sp.) in almost 500 birds from New Zealand, and Chandler (1970) found three (*Hymenolepis* sp., *Heterakis gallinarum* and (*Rhabdometra odiosa, Choanotaenia infundibulum,* and *Acuaria spinosa*) in 137 birds from British Columbia. The quail from all four of these areas were introduced. (No surveys of the helminths of California quail have been conducted within its native range.) Of these helminths, *Rhabdometra odiosa* and *Acuaria spinosa* are characteristic helminths of native Galliformes in North America. Except for *Aulonocephalus pennula,* which is characteristic of other quail and may be a characteristic helminth in California quail as well, and *Fuhrmannetta crassula,* which is characteristic of pigeons and doves, the rest of the species found in these surveys were apparently acquired from chickens.

It is also of interest that *Heterakis gallinarum,* which Williams (1966) found in almost all of the quail he examined in New Zealand, was not found in California quail in this study although it was found in two other Galliformes. *Aulonocephalus pennula* occupies the same habitat (the ceca); the abundance of *A. pennula* may have prevented infections with *Heterakis gallinarum.*

The kinds of parasites present may be markedly altered in introduced birds. Grey francolins examined by Bump and Bump (1964) in India had heartworms (*Paronchocerca rousselotti*) but no eyeworms, although black francolins (*Francolinus francolinus*) from the same general region did harbor a few *Oxyspirura* sp. We found no heartworms in the grey francolins, but all had eyeworms.

SUMMARY

One hundred fifteen exotic game birds belonging to seven species collected on the Puuwaawaa Ranch on the island of Hawaii harbored a total of eleven species of helminths. Four species (*Metroliasthes lucida, Fuhrmannetta crassula, Oxyspirura* sp., and *Aulonocephalus pennula*) were recorded from Hawaii for the first time. Thirteen new host records are reported.

Aulonocephalus lindquisti Chandler, 1935 is considered a synonym of *A. pennula* (Canavan, 1929).

Two species, *Metroliasthes lucida* and *Aulonocephalus pennula,* were apparently introduced with exotic Galliformes. Other changes in the parasite faunas of these birds are discussed.

ACKNOWLEDGMENTS

We are grateful to the owners of the Puuwaawaa Ranch, L. S. Dillingham and W. Carlsmith, for permission to collect the birds; to W. W. Becklund, U.S. National Parasite Collection, and G. R. Williams, New Zealand Wildlife Service, for providing specimens; and to J. E. Alicata for reading the manuscript.

LITERATURE CITED

ADDISON, E. M., and R. C. ANDERSON. 1969. A review of eyeworms of the genus *Oxyspirura* (Nematoda: Spiruroidea). Wildlife Diseases, no. 55. 58 pp.

ALICATA, J. E. 1964. Parasitic infections of man and animals in Hawaii. Technical Bulletin 61. Hawaii Agricultural Experiment Station, Honolulu. 138 pp.

——— 1969. Parasites of man and animals in Hawaii. S. Karger, Basel and New York. 190 pp.

ALICATA, J. E., and E. CHANG. 1939. The life history of *Hymenolepis exigua,* a cestode of poultry in Hawaii. Journal of Parasitology, vol. 25, pp. 121–127.

ARTIUKH, E. S. 1966. Osnovy tsestodologii. Tom 6. Daveneaty—lentochnye gel'minty dikikh i domashnikh zhivotnykh. (Principles of cestodology. Vol. 6. Davaineata—tapeworms of wild and domestic animals.) Akademiya Nauk SSSR, Moscow. 511 pp. [In Russian]

BUMP, G., and J. W. BUMP. 1964. A study and review of the black francolin and the gray francolin. Bureau of Sport Fisheries and Wildlife, report no. 81. Washington, D.C. 86 pp.

CAMPBELL, H., and L. LEE. 1953. Studies on quail malaria and notes on other aspects of quail populations. New Mexico Department of Game and Fish, project W-41-R. [From Gullion, 1957]

CANAVAN, W. P. N. 1929. Nematode parasites of vertebrates in the Philadelphia zoological garden and vicinity. I. Parasitology, vol. 21, pp. 63–102.

——— 1931. Nematode parasites of vertebrates in the Philadelphia zoological garden and vicinity. II. Parasitology, vol. 23, pp. 196–229.

CHANDLER, A. C. 1935. A new genus and species of Subulurinae (nematodes). Transactions of the American Microscopical Society, vol. 54, pp. 33–35.

CHANDLER, R. E. 1970. Helminth parasites of California quail (*Lophortyx californicus*) from the Okanagan Valley, British Columbia. Canadian Journal of Zoology, vol. 48, pp. 741–744.

CHING, H. L. 1961. The development and morphological variation of *Philophthalmus gralli* Mathis and Leger, 1910, with a comparison of species of *Philophthalmus* Looss, 1899. Proceedings of the Helminthological Society of Washington, vol. 28, pp. 130–138.

DOGIEL, V. A. 1964. General parasitology [English translation by Z. Kabata]. Oliver and Boyd, Edinburgh and London. 516 pp.

GOBLE, F. C., and H. L. KUTZ. 1945. The genus *Dispharynx* (Nematoda: Acuariidae) in galliform and passeriform birds. Journal of Parasitology, vol. 31, pp. 323–331.

GULLION, G. W. 1957. Gambel quail disease and parasite investigation in Nevada. American Midland Naturalist, vol. 57, pp. 414–420.

HAIR, J. D., and D. J. FORRESTER. 1970. The helminth parasites of the starling (*Sturnus vulgaris* L.): a checklist. American Midland Naturalist, vol. 83, pp. 555–564.

HWANG, J. C., N. TOLGAY, W. T. SHALKOP and D. S. JAQUETTE. 1961. Case report—*Dispharynx nasuta* causing severe proventriculitis in pigeons. Avian Diseases, vol. 5, pp. 60–65.

KASIMOV, G. B. 1956. Gel'mintofauna okhotnich'e-promyslovykh ptits otrjada kurinykh. (Helminth fauna of gallinaceous domesticated and game birds.) Akademiya Nauk SSSR, Moscow. 553 pp. [in Russian]

KELLOGG, F. E., and W. M. REID. 1970. Bobwhites as possible reservoir hosts for blackhead in wild turkeys. Journal of Wildlife Management, vol. 34, pp. 155–159.

KROGSDALE, J. T. 1950. Survey of endoparasites in California Valley quail of the Palouse area. Transactions of the American Microscopical Society, vol. 69, pp. 398–402.

KRYGIER, B. B., and R. W. MACY. 1969. The eye fluke *Philophthalmus megalurus* (Cort) (Trematoda: Philophthalmidae) in the dipper, *Cinclus mexicana,* in Oregon. Journal of Parasitology, vol. 55, p. 78.

LEVINE, N. D. 1961. Protozoan parasites of domestic animals and of man. Burgess Publishing Co., Minneapolis. 412 pp.

——— 1968. Nematode parasites of domestic animals and of man. Burgess Publishing Co., Minneapolis. 600 pp.

LEWIN, V. 1971. Exotic game birds of the Puu Waawaa Ranch, Hawaii. Journal of Wildlife Management, vol. 35, no. 1, pp. 141–155. 2 figs.

MADSEN, H. 1950. Studies on species of *Heterakis* (nematodes) in birds. Danish Review of Game Biology, vol. 1, pp. 1–43.

MAXFIELD, B. G., W. M. REID, and F. A. HAYES. 1963. Gastrointestinal helminths from turkeys in southeastern United States. Journal of Wildlife Management, vol. 27, pp. 261–271.

MOVSESSIAN, S. O. 1966. Revizija roda *Raillietina* Fuhrmann, 1920 (Cestoda: Davainii-

dae). (Revision of the genus *Raillietina* Fuhrmann, 1920; Cestoda: Davainiidae.) Trudy Vsesoiuznogo Instituta Gel'mintologii imeni Skrjabin, vol. 13, pp. 17–40. [in Russian]

REID, W. M. 1962. Chicken and turkey tapeworms. Handbook to aid in identification and control of tapeworms found in the United States of America. Georgia Experimental Station, Athens. 71 pp.

SCHWABE, C. W. 1950. Studies on *Oxyspirura mansoni,* the tropical eyeworm of poultry. III. Preliminary observations on eyeworm pathogenicity. American Journal of Veterinary Research, vol. 11, pp. 286–290.

SCHWARTZ, C. W., and E. R. SCHWARTZ. 1949. A reconnaissance of the game birds in Hawaii. Territory of Hawaii, Board of Commissioners of Agriculture and Forestry, Honolulu. 168 pp.

——— 1951. An ecological reconnaissance of the pheasants in Hawaii. Auk, vol. 68, pp. 281–314.

SELF, J. T., and J. L. BOUCHARD. 1950. Parasites of the wild turkey, *Meleagris gallapavo intermedia* Sinnet, from the Wichita Mountains Wildlife Refuge. Journal of Parasitology, vol. 36, p. 502.

SKRJABIN, K. I., A. A. SOBOLEV, and V. M. IVASHKIN. 1965. Osnovy nematodologii. Tom 14. Spiruraty zhivotnykh i cheloveka i vyzyvaemye imi zabolevanija. Chast' tret'ja, Akuaroidei. (Principles of nematodology. Vol. 14. Spirurata of animals and man and the diseases produced by them. Part 3. Acuaroidea.) Akademiya Nauk SSSR, Moscow. 572 pp. [in Russian]

SPASSKY, A. A., and N. M. JURPALOVA. 1964. Novye rod tsepnee domashnikh kur—*Orientolepis* (Cestoda, Hymenolepididae). (A new genus of tapeworm from domestic fowl—*Orientolepis* (Cestoda, Hymenolepididae). Trudy Gel'mintologicheskii Laboratorii Akademiya Nauk SSSR, vol. 14, pp. 197–200. [in Russian]

TALIAFERRO, W. J. 1959. Rainfall of the Hawaiian Islands. State of Hawaii Water Authority, Honolulu. 394 pp.

WEBSTER, J. D. 1947. Helminths from the bob-white in Texas, with descriptions of two new cestodes. Transactions of the American Microscopical Society, vol. 66, pp. 339–343.

WEBSTER, J. D., and C. J. ADDIS. 1945. Helminths from the bob-white quail in Texas. Journal of Parasitology, vol. 31, pp. 286–287.

WILLIAMS, G. R. 1966. A study of California quail in New Zealand with particular reference to population ecology. Unpublished Ph.D. Dissertation, University of Canterbury, Christchurch, New Zealand.